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## The Antarctic Ice Sheet, Sea Ice, and the Ozone Hole: Satellite Observations of How They are Changing

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Antarctica is the Earth's coldest and highest continent and has major impacts on the climate and life of the south polar vicinity. It is covered almost entirely by the Earth's largest ice sheet by far, with a volume of ice so great that if all the Antarctic ice were to go into the ocean (as ice or liquid water), this would produce a global sea level rise of about 60 meters (197 feet). The continent is surrounded by sea ice that in the wintertime is even more expansive than the continent itself and in the summertime reduces to only about a sixth of its wintertime extent. Like the continent, the expansive sea ice cover has major impacts, reflecting the sun's radiation back to space, blocking exchanges between the ocean and the atmosphere, and providing a platform for some animal species while impeding other species. Far above the continent, the Antarctic ozone hole is a major atmospheric phenomenon recognized as human-caused and potentially quite serious to many different life forms.

Satellites are providing us with remarkable information about the ice sheet, the sea ice, and the ozone hole. Satellite visible and radar imagery are providing views of the large scale structure of the ice sheet never seen before; satellite laser altimetry has produced detailed maps of the topography of the ice sheet; and an innovative gravity-measuring two-part satellite has allowed mapping of regions of mass loss and mass gain on the ice sheet. The surrounding sea ice cover has a satellite record that goes back to the 1970s, allowing trend studies that show a decreasing sea ice presence in the region of the Bellingshausen and Amundsen seas, to the west of the prominent Antarctic Peninsula, but increasing sea ice presence around much of the rest of the continent. Overall, sea ice extent around Antarctica has increased at an average rate of about 17,000 square kilometers per year since the late 1970s, as determined from satellite microwave data that can be collected under both light and dark conditions and irrespective of whether clouds are in the way between the surface and the satellite. In contrast, the highest quality satellite measurements of the ozone hole use ultraviolet light, which requires daylight conditions. Still, satellite ultraviolet measurements of the ozone hole have also been made since the late 1970s, and these show a marked increase in the area and depth of the ozone hole in the 1980s and early 1990s, followed by a welcome leveling off of both measures since the mid-1990s.

Overall, satellites are providing remarkably informative views of the extraordinary Antarctic region.